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(54) IMPROVEMENTS IN OR RELATING TO THE COMPACTING OF POWDERED MATERIALS

(71) We, ENGLISH CLAYS LOVERING POCHIN AND COMPANY LIMITED, a British Company, of John Keay House, St. Austell, Cornwall, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to the compaction of particulate solid materials and is concerned with a method of compacting particulate solid materials, for example powdered or pelletised materials, and with an apparatus for carrying out said method.

At the present time, particulate solid materials, which may be, for example, pigments, fillers, pharmaceuticals, pesticides, fertilisers or animal foodstuffs, are transported either in bulk or in disposable, non-returnable containers, for example in cardboard cartons or in sacks or bags made of paper, a sheet plastics material or a woven material for example jute. However, a mass of particulate solid material almost invariably contains large quantities of entrained gas, generally air, and in order to reduce the bulk of the material and make the best use of the capacity of, for example, the hold of a ship or a railway box car, it is necessary to reduce the amount of gas, usually air, entrained in the mass of particulate solid material and/or to compress the mass of particulate solid material before, during or immediately after the process of filling the container. Some of the known methods of achieving this object are disclosed on pages 8—62 and 8—63 of the Chemical Engineer's Handbook by John H. Perry, 4th Edition, published by the McGraw-Hill Book Company of New York and London in 1963. However, it has not been possible heretofore to compact into free-standing blocks a large mass of many particulate solid materials which contain a large quantity of entrained gas because the compressed gas tends to cause a compacted block of the particulate solid material to crack and disintegrate. It will also be appreciated that the bulk densities of particulate solid materials vary over a wide range so that, if the materials are sold by weight, a wide variety of container sizes are at present necessary.

Accordingly, in one aspect the present invention provides a method of compacting a particulate solid material which comprises the steps of applying pressure to the mass of particulate solid material in a mould to compact the particulate solid material whilst in the presence of a plurality of elongate members which extend into the cavity of the mould but do not pass completely therethrough, and subsequently retracting the elongate members from the particulate solid material whereby compressed gas trapped in said particulate solid material can escape therefrom through the holes formed therein by said elongate members.

Advantageously, the compaction of the particulate solid material to the desired bulk density is effected in more than one stage. Thus, in the first stage the pressure applied to the mass of particulate solid material is such that the particulate solid material is compacted to, say, 75% or more of the desired bulk density, the elongate members are then withdrawn, and optionally the pressure applied to the partially compacted particulate solid material released, so that compressed gas can escape, the elongate members are then re-introduced into the holes formed during the first stage and compaction of the particulate solid material completed or carried forward one more stage. Generally, it will be found to be advantageous for the pressure applied in the second stage, and in each subsequent stage if any, to be higher than the pressure applied in the preceding stage. The number of stages employed to obtain a required bulk density depends essentially on the nature and degree of division of the particulate solid material being treated and on the amount of entrapped gas, but usually not more than eight stages will be required.

The pressure which has to be applied to the particulate solid material to reach a particular bulk density and/or to obtain a free-standing block also depends on the nature and

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degree of division of the particulate solid material being treated and on the amount of entrapped gas, but it has been found that for most materials the applied pressure will normally lie in the range 50 to 600 lbs/sq. in.

The elongate members can be introduced into the mass of particulate solid material before or during the compaction thereof. It is advantageous to withdraw the elongate members from the compacted particulate solid material before the applied pressure is released so as to ensure that the block does not crack before the compressed and entrapped gas has escaped. However, the method of the invention can be used to reduce the bulk density of a mass of a particulate solid material without necessarily forming a free-standing block; and in this case, for example, there may be no advantage in having a short interval between the withdrawal of the elongate members and the release of the applied pressure.

In another aspect, the present invention provides a method of transporting a particulate solid material which method comprises compacting the particulate solid material by a method according to the invention, and transporting the compacted particulate solid material thus obtained to the desired location.

The present invention also provides an apparatus for compacting a particulate solid material, which apparatus comprises a mould having an unperforated base member and adapted to receive a mass of particulate solid material to be compacted, a plurality of elongate members and means for introducing said elongate members into and for withdrawing said elongate members from said mould, and press means for applying pressure to the mass of particulate solid material in said mould, the arrangement being such that said elongate members extend into the mould cavity but do not pass completely therethrough.

In a preferred embodiment of the apparatus of the invention the plurality of elongate members are in the form of a plurality of tapered needles mounted on a frame; and the press means for applying pressure to the mass of particulate solid material is provided with a plurality of apertures corresponding in number to the number of needles and spaced so that, during operation of the apparatus, the tapered needles can pass through the apertures into the mass of particulate solid material in the mould. During compaction of the mass of particulate solid material, the tapered needles extend substantially throughout the mass of particulate solid material, sealing means being provided between the needles and the sides of the apertures in the press and also between the press and the sides of the mould to minimise the passage of solid material through the clearances between these members.

The mould in which the particulate solid material is compacted is preferably in the form of a mould box assembly comprising side members and a platen which is moveable within and relative to said side members. Advantageously, the press and mould box assembly are constructed so that the pressure acting on the top layer of particulate solid material and the pressure acting on the bottom layer of particulate solid material in the mould are equalised, whereby uniform compaction throughout the block or tablet is achieved.

It is generally found to be advantageous for the elongate members to be substantially uniformly spaced. The optimum spacing between the elongate members depends on the ease with which the gas entrapped in the particulate solid material can pass through the particulate solid material. The maximum spacing between individual elongate members, and also between the elongate members and the sides and base of the mould, can be determined experimentally for any particular material, but it will generally be found that the spacing should be in the range ½ inch to 2½ inches and, in most cases, in the range 1 inch to 2 inches.

For a better understanding of the invention and to show how the same may be carried into effect, reference will now be made, by way of example, to the accompanying drawings in which:—

Figure 1 is a front elevation of one embodiment of apparatus in accordance with the present invention;

Figure 2 is a side elevation of the embodiment of the apparatus shown in Figure 1;

Figure 3 is a section on the line III—III of Figure 1;

Figures 4, 5 and 6 are a plan view, a front elevation and a side elevation of the mould box of the embodiment of the apparatus shown in Figures 1, 2 and 3;

Figure 7 is a cut-away isometric view of part of the apparatus shown in Figures 1 to 6;

Figure 8 is a diagrammatic isometric view of a second embodiment of apparatus in accordance with the invention;

Figure 9 is a plan view of a third embodiment of apparatus in accordance with the invention;

Figure 10 is a sectional elevation on the line X—X of Figure 9;

Figure 11 is a sectional elevation on the line XI—XI of Figure 9;

Figure 12 is a detail, on an enlarged scale, of the embodiment of the apparatus shown in Figures 9, 10 and 11; and

Figure 13 shows schematically the four stages in the operation of the apparatus shown in Figures 9 to 12.

Referring first to Figures 1 to 7 of the accompanying drawings, it will be seen that the embodiment of the apparatus illustrated therein includes a platen 1 resting on rails 31 which are attached to a base 14. The base 14 slidably engages posts 15 and 16. The platen 1 comprises plates 25 and 26, two parallel I-section

bars 27 and 28, and two end plates 29 and 30. The shape and construction of the platen 1 are governed by the need for strength and stiffness to withstand the applied pressure and by the fact that the platen travels upwards in a mould box (described hereinafter) a distance of approximately one half inch during the compacting sstage in the operation of the apparatus. The platen 1 must be made sufficiently deep to enable it to be guided upwards in the mould box.

The base 14 is linked by struts 4, 5 and 6 to a triangular top member 17. The top member 17 is connected to one end of pivoted arms 7 and 8. The other end of the pivoted arms 7 and 8 is connected to column 9 which is connected via a piston head 10 and struts 18 to a plunger 13. The plunger 13 is raised or lowered hydraulically by means of pistons 11 and 12, and the linkage system, described above, connecting the plunger 13 with the base 14, and thus with the platen 1, ensures that when the plunger 13 is lowered the platen 1 is raised. In this way, substantially equal pressures are applied to the top and bottom layers of the mass of particulate solid material in the mould box.

The apparatus is also provided with a plurality of elongate members in the form of tapered needles 21 which are uniformly spaced about $1\frac{1}{2}$ inches apart and which are supported by a frame 22. The frame 22 can be raised or lowered relative to the plunger 13 by pistons hydraulically controlled from cylinders 23 and 24. The needles 21 pass through a corresponding number of apertures formed in the plunger 13. The apertures in plunger 13 are provided with labyrinth seals which engage the needles 21 when the latter are fully extended through the apertures in plunger 13. The plunger 13 is also provided with a labyrinth seal 32 around its edge for engagement with the sides of the mould box (described hereinafter).

A mould box assembly is formed from the platen 1, and a mould box 34 consisting of side members 36 and 37. The side members 36 and 37, which are attached to a turntable 40, as shown in Figures 4, 5 and 6, each comprise adjoining pairs of sides hinged at 41 and arranged so that they can be opened by from 1/8 to 1/4 inch. This enables a block of compacted particulate solid material to separate from the side members and be ejected. Three cams 39 rotating about axes which pass through holes 38 are provided to act upon the lower surface of the top plate 25 of the platen 1 in a way such that the platen 1 is held at its highest position when the compaction stage is complete.

After compaction, the base 14, together with the rails 31, is lowered and the plunger 13, together with the needles 21, is raised so as to clear completely the side members of the mould box. The platen 1 is now clear of the rails 31, but remains in contact with the block of compacted material. The turntable 40 is then rotated to the filling and discharge position, and the platen 1 is released by the cams and the mould box opened slightly so as to release the compacted block.

A compacted block 33, showing the holes in its upper surface, is shown in Figure 7 which also shows the labyrinth seal 32 and part of the mould box 34.

In operation simultaneous compaction and deaeration of a mass of particulate solid material are achieved by introducing the mass of particulate solid material with its entrained air into the mould box assembly. Pressure is then applied to the mass of particulate solid material by means of the platen 1 and plunger 13. At the same time, the tapered needles 21 penetrate the mass of particulate solid material; and during compaction the needles 21 form partial seals in the plunger 13 which prevent egress of the solid material but allow a small quantity of air to escape, thus enabling the solid material adjacent to the needles 21 and the plunger 13 to compact and increase in bulk density, while remaining permeable to air under pressure. The needles 21 are then withdrawn and the entrapped air is allowed to breath from the holes formed by the elongate members. The cycle is repeated until the desired bulk density is achieved or the maximum degree of compaction obtainable is reached.

The particulate solid material to be compacted is allowed to flow into the mould box assembly from, for example, a chute or hopper and, as noted above, is subjected to one or more compaction cycles. One cycle of the apparatus comprises a compression stroke with the needles 21 extending into the mass of particulate solid material, a dwell time with the plunger 13 in the lowered position but with the needles 21 withdrawn to allow the escape of gas, and a release stroke in which the plunger 13 is raised. With the apparatus described above, the speed of the plunger 13 and the clearance between the needles 21 and the plunger 13 and between the plunger 13 and the mould box 34 each depend on the particulate solid material to be compacted and on the applied pressure but the following figures indicate the range over which it has been found that these parameters can normally be varied:

1. Plunger speed: — 0.05 to 1.0 feet per second

2. Clearance between needles and plunger with needles fully extended: — 0.005 to 0.125 inches

3. Clearance between plunger and mould box: — 0.005 to 0.125 inches.

In one operation using the apparatus described above to compact powdered kaolin clay there was produced a standard block of dimensions 20 inches by 8 inches by $5\frac{1}{2}$ inches so that, with the bulk density of the powdered

kaolin clay increased to 108 lbs per cubic foot, each block contained 25 kilograms of kaolin clay. Forty blocks thus comprised a metric ton and could be made up into a unit load of volume and shape which complied with international satndards.

Referring now to the embodiment of the apparatus shown in Figure 8, it will be seen that this embodiment comprises four stations A, B, C and D at which there occur, respectively, filling of the mould, first stage compaction, second stage compaction, and ejection of the compacted block. There are provided four mould boxes 134*a*, 134*b*, 134*c* and 134*d* which are rigidly mounted on a toothed ring 140. The toothed ring 140 is supported by a wire-race ball bearing (not shown) on a fixed central support ring 142 which is free to rotate about its axis. The toothed ring 140 is driven by means of an electric motor 150 through a gear box 151 and an indexing crank 152 which imparts reciprocating motion to a toothed sector 153 through a coupling rod 154. The toothed sector 153 engages a pinion wheel 155 which drives a second pinion wheel 156. The pinion wheel 156 is enmeshed with the toothed ring 140 and is driven through a clutch 157 which engages when the toothed sector 153 is moving in the direction which will advance the toothed ring 140 in a clockwise direction and which disengages when the toothed sector 153 is moving in the reverse direction. In this way, the toothed ring 140 and the four mould boxes 134 are rotated in discrete steps of 90°.

At the filling station A, a pre-weighed quantity of feed material is delivered to a vibrating drop chute 160 which includes an approximately S-shaped duct 161. The S-shaped duct 161 can be rotated about an axle 162 from a substantially horizontal discharge position (as shown) to an inclined filling position in which the pre-weighed feed material can accumulate without overflowing from the discharge end of the duct. A charge of feed material is allowed to accumulate in the S-shaped duct 161 in its inclined position, and the duct 161 is then rotated to its horizontal position in order to discharge its contents into a mould box assembly. Vibrators 163 are provided to ensure rapid discharge of the feed material from the chute.

During its passage from the filling station A to the first compaction station B the filled mould box assembly passes beneath a roller 169 which falls lightly into the mould box assembly and levels the load of feed material.

At the first and second compaction stations B and C there are provided two compaction assemblies constructed in a manner similar to that described hereinbefore in connection with Figures 1, 2, 3, 4, 5, 6 and 7. The compaction assembly at station C is adapted to operate at a higher plunger face pressure than is the compaction assembly at station B.

At the ejection station D the mould box is opened by 1/8 to 1/4 inch and the lower platen is raised by means of an ejector 170 until the bottom of the compacted block of particulate solid material is level with or slightly higher than the top of the side members of the mould box. The ejector 170 is raised by means of two rods 171 and 172 connected to hydraulic rams (not shown). When the compacted block is clear of the side members of the mould box it is pushed by a long-travel hydraulic ram 173 across a fixed platform and onto an endless conveyor 174 which transfers it to a wrapping station (not shown) where it can be wrapped in paper or other suitable material.

The hydraulic cylinders which control the movement of the needles, platents and plungers of the compacting assemblies, and the hydraulic cylinder which ejects the compacted blocks, are controlled by hydraulic valves 180 which are actuated by cams 181 carried on a spindle 182. The spindle 182 is rotated by means of a bevel gear drive 183 from the main gear box 151 through a clutch 184. The vibrating drop chute 160 is raised and lowered mechanically by means of a cam 185 and linkage 186.

Sensing devices (not shown) are provided to ensure that all conditions are correct before any stage in the operation is performed. If any conditions are incorrect, for example if no pre-weighed feed is supplied to the chute 160 or if any of the rams have not retracted, the clutches 157 and 184 are automatically disengaged and no further rotation of the toothed ring 140 is permitted until the fault has been remedied.

A control panel (not shown) is provided to accommodate all switches and instruments associated with the apparatus.

Referring now to Figures 9 to 13, there is shown an embodiment of the apparatus of the invention which differs from the first and second embodiments in that the lower platens of the compaction assemblies do not move during the compaction stages. The compaction assemblies have rigid frameworks to which the upper ends of the hydraulic rams for the plungers are secured, and the mould boxes are free to move vertically during each compaction stage.

As in the second embodiment described above with reference to Figure 8, the apparatus comprises a filling station A, two compacting stations, B and C, and an ejection station D.

At the filling station A, particulate solid material is fed into a mould box assembly 234a by means of a chute (not shown) similar to that described above with reference to Figure 8.

At the compaction stations B and C, each compaction assembly includes a lower platen 201 supported on a fixed stool 231 attached to a bottom member 214 of a frame of I-section girders. A plunger 213, which is shown partly in section in Figure 10, is raised or lowered hydraulically by means of pistons 211

and 212. The pistons 211 and 212 are secured to a piston head 210 which is connected to the plunger 213 by twelve struts 218.

There is also provided a plurality of needles 221 which are supported by a frame 222. The frame 222 can be raised or lowered by pistons hydraulically controlled from cylinders 223 and 224. The needles 221 pass through apertures formed in the the plunger 213, each aperture having a labyrinth seal (not shown) which engages the needles when the latter are fully extended through the plunger 213.

A column 290 is attached at its lower end to the frame 222 and its upper end slides in a tube 291 attached to the piston head 210. The tube 291 in turn slides in a tube 209 which is rigidly mounted to the top member 217 of the frame of I-section girders. The column 290 and the tubes 291 and 209 co-operate to keep the piston head 210, the plunger 213 and the frame 222 horizontal. The correct orientation of the piston head 210 and the frame 222 is maintained by making their ends slide in channels 295 and 296 which are secured to the side members of the frame of I-section girders.

Four moulds boxes 234*a*, 234*b*, 234*c* and 234*d* are rigidly mounted on a turret 240 which rotates on a shaft 242 which runs in three ball-bearing races 243, 244 and 245.

The turret 240 is driven by means of an electric motor through a mechanical clutch and splined shaft 250 to a bevel-gear drive 251. The drive is transmitted by sput gears 252 to a Geneva arm 253 with one roller which engages a Geneva wheel 254 with four slots disposed at 90° intervals. The Geneva wheel 254 is carried on the shaft 242. The Geneva mechanism ensures that the turret rotates in steps of exactly 90° and its speed of rotation is 15 r.p.m. which gives a rotation period of 1 second followed by a stationary period of 3 seconds during which filling, compacting and ejection operations are performed.

During the rotation period the platens 201 slide on arcuate rails and the slide members of the mould boxes are supported by rollers 264 which run on a fixed arcuate rail 265 for the greater part of the cycle. However, while the mould box is resting at either of the compacting assemblies or travelling between the two, the rollers 264 run on a retractable arcuate rail 266 which is retracted by means of a hydraulic ram 267 through a linkage 268.

During the compacting stages the rail 266 is retracted so that the side members of the mould box are free to move up and down, the orientation being maintained by a shoe 246 sliding in a slot 247. In this way the face pressure of the bottom platen is always equal to the face pressure of the plunger during each compacting stage. If the face pressure of the plunger exceeds that of the bottom platen the side members of the mould box will fall to equalise the pressures and vice versa.

At the ejection station D the compacted block is ejected by an apparatus essentially the same as that described for the second embodiment. The side members of the mould box are opened slightly or closed by means of the arrangement shown in Figure 12. An eccentric pin 275 has a head 276 provided with two studs 277a and 277b which contact two fixed cams 278a and 278b as the mould box assembly enters or leaves the ejection station thus opening and closing the side members of the mould box. As the pin 275 is rotated the flanges 279 which are attached to the side member 237 are moved relative to the collar 274 attached to side member 236 tbus separating the two side members by from 1/8 to 1/4 inch.

The hydraulic cylinders and other parts of the apparatus are actuated by cams which are mounted in a control box 299, the drive to which is taken from the bevel gear drive 251 by a shaft 298 and bevel gear 297.

The relative positions of a mould box at each station is shown in Figure 13, the line X—X representing the position of the top of the mould box at the beginning and end of the operation.

The invention is illustrated by the following Examples in which there was used the apparatus described above with reference to Figures 1 to 7.

Example 1

Pelletised china clay comprising particles ranging in size from ¼″ in diameter down to dust and having a moisture content of 10% and an initial bulk density of 44 lbs per cubic foot were compacted in the apparatus of the invention in two stages to form a block having a bulk density of 114 lbs per cubic foot. The plunger speed was 0.25 feet per second, the plunger face pressure in the first stage was 100 lbs/sq.in., and in the second stage was 365 lbs/sq.in., the clearance between the needles and the plunger was 1/32 inch, and the clearance between the plunger and the mould box 1/16 inch.

Example 2

Lump china clay comprising particles ranging in size from ¼″ in diameter down to dust and having a moisture content of 10% and an initial bulk density of 55 lbs per cubic foot were compacted in one stage to form a block having a bulk density of 120 lbs per cubic foot. The plunger face pressure was 365 lbs/sq.in., whilst the plunger speed, needle clearance and mould clerance were as specified in Example 1.

Example 3

Milled china clay comprising a powder consisting essentially of particles smaller than No. 300 British Standard Mesh and having a moisture content of 1% and an initial bulk density of 15 lbs per cubic foot was compacted in eight stages to form a block having a bulk density 70 lbs per cubic foot. The plunger

speed was 1 inch per second, the needle and mould clerance were as specified in Example 1, and the plunger face pressure was 100 lbs/sq.in. in the first stage and 365 lbs/sq.in., in the second to eighth stages.

In addition to the compaction of clays the method and apparatus of the present invention can be used for compacting, for example, metallic oxides, silica, silicates, carbonates, talcs, fillers, organic and inorganic pigements, dyestuffs, carbon blacks, pharmaceuticals, pesticides, fertilisers and foodstuffs.

WHAT WE CLAIM IS:—

1. A method of compacting a particulate solid material which comprises the steps of applying pressure to the mass of particulate solid material in a mould to compact the particulate solid material whilst in the presence of a plurality of elongate members which extend into the cavity of the mould but do not pass completely therethrough, and subsequently retracting the elongate members from the particulate solid material whereby compressed gas trapped in said particulate solid material can escape therefrom through the holes formed therein by said elongate members.

2. A method according to Claim 1, wherein said elongate members are introduced into the mould at the same time as pressure is applied to the particulate solid material therein.

3. A method according to Claim 1 or 2, wherein said elongate members are withdrawn from said mass before the pressure applied to the mass is released.

4. A method according to Claim 1, 2 or 3, wherein said elongate members, when extending into the mould, are separated from the walls thereof by at least ¼ inch.

5. A method according to Claim 1, 2, 3, or 4 wherein the compaction of the particulate solid material to the desired bulk density is effected by the application of pressure more than once to the mass of particulate material.

6. A method according to Claim 5, wherein the particulate solid material is compacted to at least 75% of the desired bulk density during the first application of pressure.

7. A method according to any one of Claims 1 to 6, wherein the pressure applied to the particulate solid material in the mould is in the range of from 50 to 600 lbs/sq.in.

8. A method according to any one of the preceding claims, wherein said particulate solid material is a clay.

9. A method of compacting a particulate solid material substantially as hereinbefore described with reference to the accompanying drawings.

10. A method of transporting a particulate solid material, which method comprises compacting the particulate solid material by a method as claimed in any one of the preceding claims, and transporting the compacted particulate solid material thus obtained to the desired location.

11. An apparatus for compacting a particulate solid material, which apparatus comprises a mould having an unperforated base member and adapted to receive a mass of particulate solid material to be compacted, a plurality of elongate members and means for introducing said elongate members into and for withdrawing said elongate members from said mould, and press means for applying pressure to the mass of particulate solid material in said mould, the arrangement being such that said elongate members extend into the mould cavity but do not pass completely therethrough.

12. An apparatus as claimed in Claim 11, wherein said plurality of elongate members are in the form of a plurality of tapered needles mounted on a frame.

13. An apparatus as claimed in Claim 11 or 12, wherein said press means comprises a plunger provided with a plurality of apertures corresponding in number to the number of elongate members and spaced so that, during operation of the appartus, the elongate members can pass through the apertures into the mass of particulate solid material in the mould.

14. An apparatus as claimed in Claim 13, wherein said apertures are each provided with a labyrinth seal.

15. An apparatus as claimed in Claim 13 or 14, wherein the edge of said plunger which engages with the sides of the mould is provided with a labyrinth seal.

16. An apparatus as claimed is any one of Claims 11 to 15, wherein said press means further comprises first means whereby, during the compaction of the particulate solid material, the pressure acting on the top layer of said particulate solid material and the pressure acting on the bottom layer of said particulate solid material can be equalised.

17. An apparatus as claimed in any one of Claims 11 to 16, wherein said press means is operated hydraulically.

18. An apparatus as claimed in Claim 16 or 17, wherein said first means comprises a plunger which, during the compaction of the particulate solid material, acts on one surface and a base which is connected by a linkage system to said plunger.

19. An apparatus as claimed in Claim 18, wherein said linkage system comprises a lever which is pivotally attached at one end to a column which is rigidly secured to said plunger, and at its other end pivotally attached to a top member which is rigidly secured to one or more struts which in turn is or are rigidly connected at the end remote from said top member to said base.

20. An apparatus as claimed in Claim 19, wherein said top member is triangular and is rigidly connected to three struts which are rigidly connected at their ends remote from said top member to said base.

21. An apparatus as claimed in Claim 19,

or 20, wherein said column is rigidly secured to a plate which in turn is rigidly secured to said plunger by a plurality of struts.

22. An apparatus as claimed in Claim 21, wherein said plate is a piston head which receives the action of a plurality of pistons.

23. An apparatus as claimed in Claim 22, wherein the ends of the piston casings remote from said piston head are rigidly secured to the top member.

24. An apparatus as claimed in any one of Claims 11 to 23 wherein said elongate members are supported by a frame which, in use, can be raised or lowered relative to the mould by pistons.

25. An apparatus as claimed in Claim 24, wherein said pistons are operated hydraulically.

26. An apparatus as claimed in any one of Claims 11 to 25, wherein the elongate members are substantially uniformly spaced apart.

27. An apparatus as claimed in any one of Claims 11 to 26, wherein the spacing between individual elongate members lies in the range of from $\frac{1}{2}''$ to $2\frac{1}{2}''$.

28. An apparatus as claimed in any one of Claims 11 to 27, wherein said mould comprises side members and wherein said unperforated base member is a platen which is movable within and relative to said side members.

29. An apparatus as claimed in Claim 28, wherein said side members are constructed and arranged so that they can be opened to facilitate separation of a block of compacted solid particulate material therefrom.

30. An apparatus substantially as hereinbefore described with reference to, and as illustrated in, Figures 1 to 7 of the accompanying drawings.

31. An apparatus as claimed in any one of Claims 11 to 30, wherein the apparatus comprises four stations, wherein (i) the firt station comprises means for filling a mould, (ii) the second and third stations each comprise means for performing a compacting action upon a mass of particulate solid material within a mould, and (iii), the fourth station comprises means for ejecting from a mould a compacted block formed from a mass of particulate solid material.

32. An apparatus as claimed in Claim 31, which further comprises means whereby a mould can be moved automaticallly from one station to an adjacent station.

33. An apparatus as claimed in Claim 32, wherein said means comprises a toothed ring to which four moulds are secured.

34. An apparatus as claimed in Claim 31, 32 or 33, wherein said first station comprises a vibratable drop shute including a duct which can be rotated from a first position at which it can accept and hold a quantity of particulate solid material to a second position at which it can deliver the particulate solid material to a mould, and means for vibrating said drop shute; and wherein said fourth station comprises an endless conveyor, means for raising a compacted block until its lowest portion is at least as high as the side wall of the mould and means for pushing the compacted block from said mould onto said endless conveyor.

35. An apparatus as claimed in Claim 31, 32, 33 or 34, wherein there is further provided a roller situated between said first station and said second station at a position such that, in use, it levels the contents of a mould which is moving from said first station to said second station.

36. An apparatus as claimed in any one of Claims 31 to 35, wherein there are provided hydraulic cylinders and linkages controlled by hydraulic valves which, in use, are actuated by a cam carried on a spindle which is driven by a motor, said hydraulic cylinders and linkages serving to control the movement of the elongate members, the press means, and the ejection means.

37. An apparatus as claimed in Claim 36, which further comprises sensing devices which can prevent the apparatus from operating unless conditions are such that a successful operation can be performed.

38. An apparatus substantially as hereinbefore described with reference to, and as illustrated in, Figure 8, or Figures 9 to 13, of the accompanying drawings.

39. A block of compacted material whenever formed by a method or in an apparatus as claimed in any one of the preceding claims.

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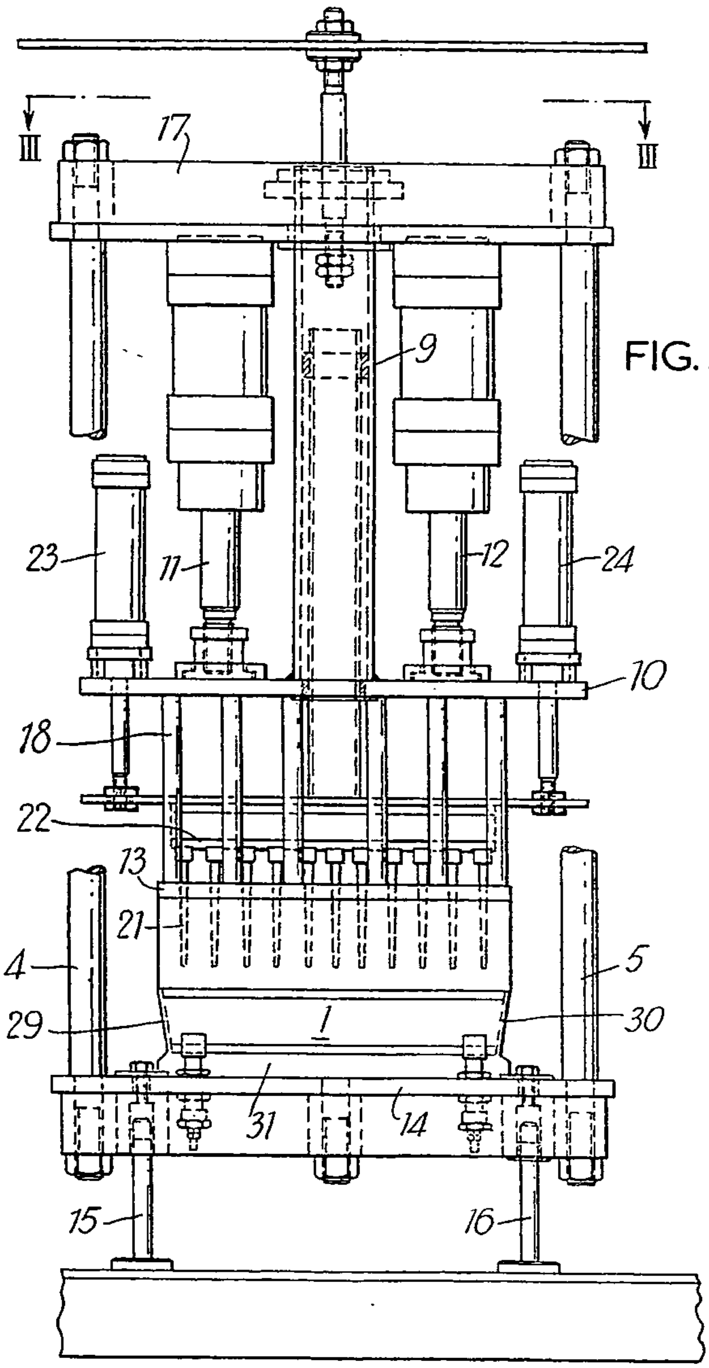

FIG. 1

1258051 COMPLETE SPECIFICATION

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Sheet 1

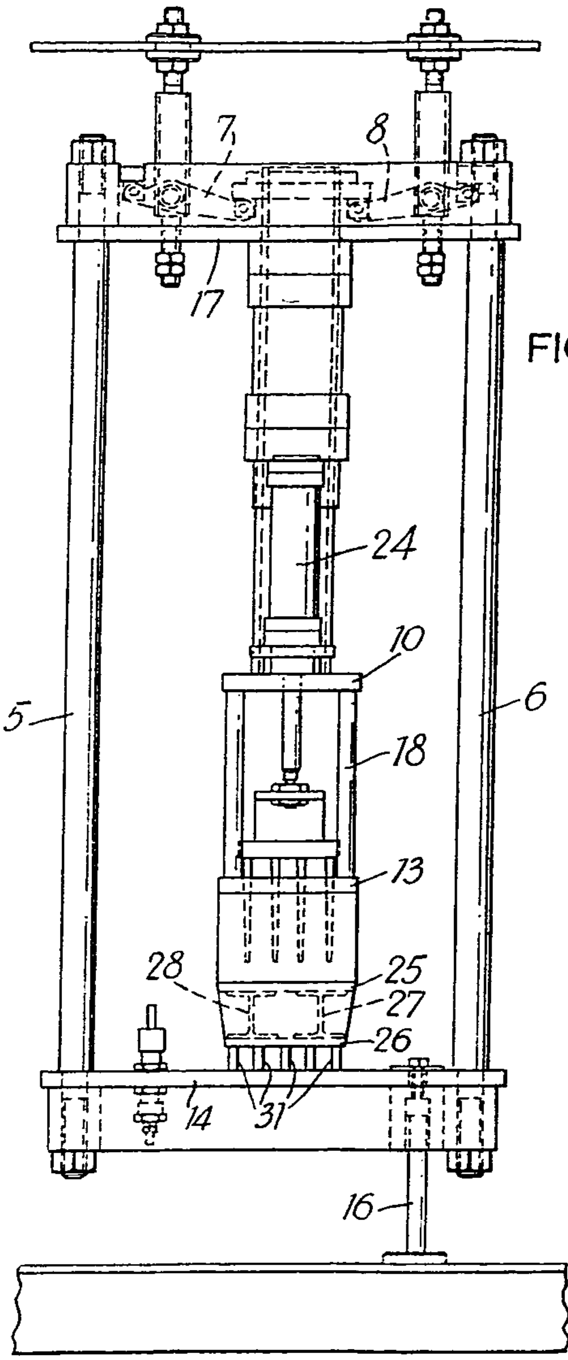


FIG.2

1258051 COMPLETE SPECIFICATION

8 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 1

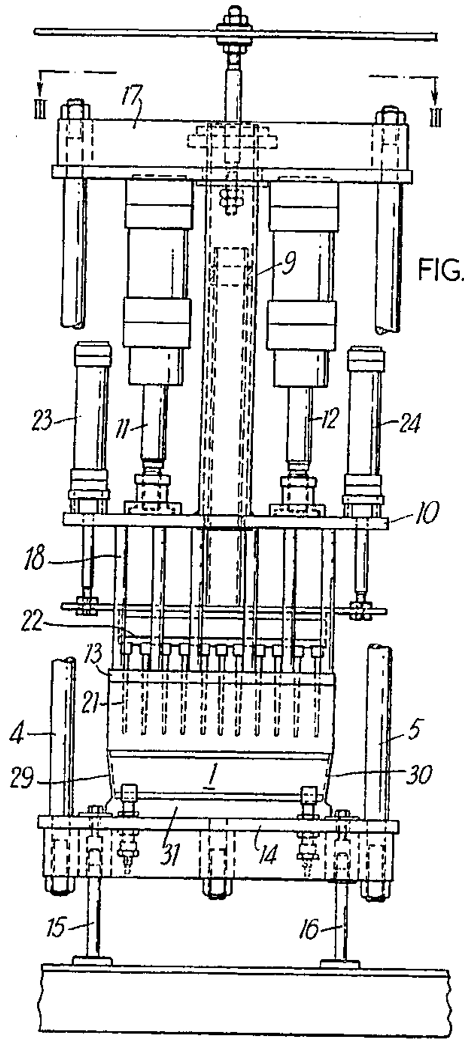


FIG. 1

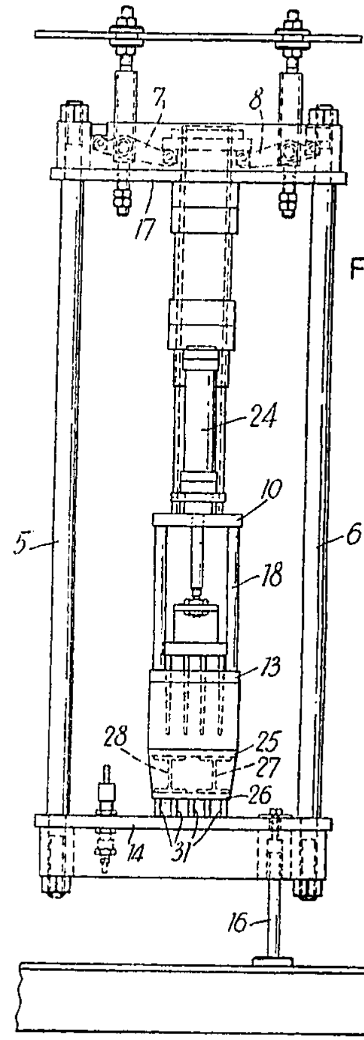


FIG. 2

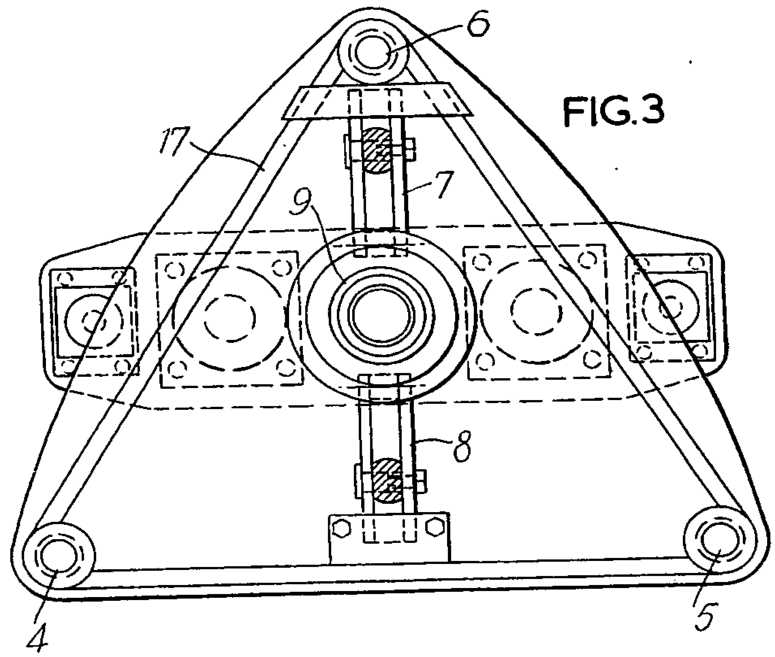
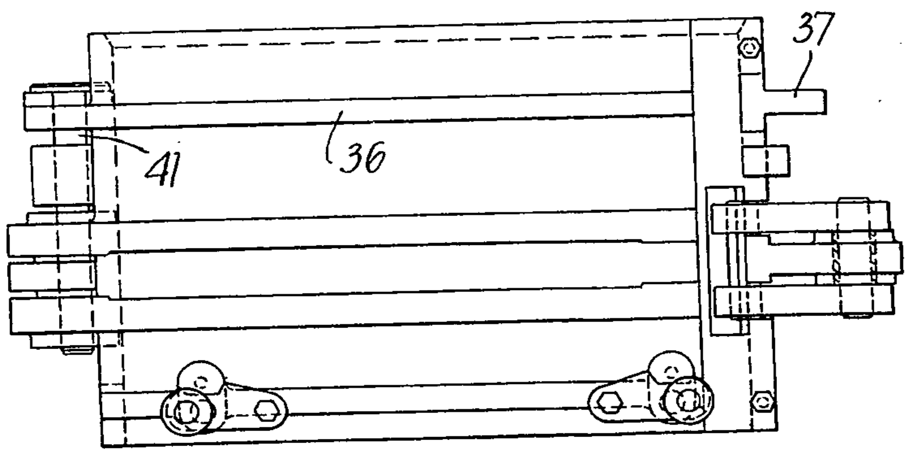


FIG.3

FIG.5



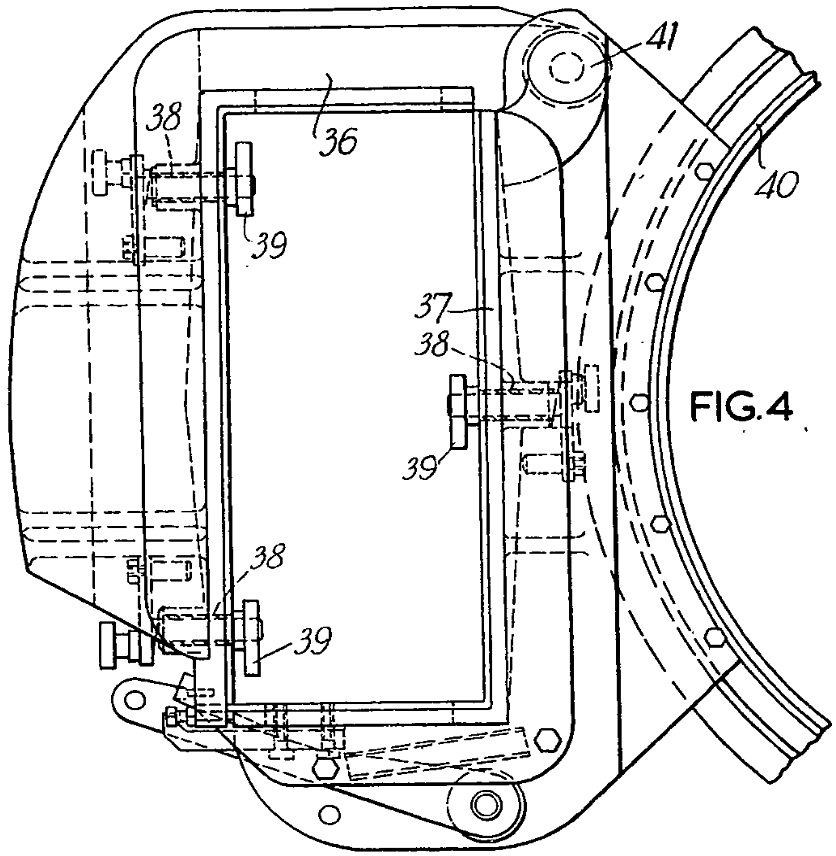


FIG.4

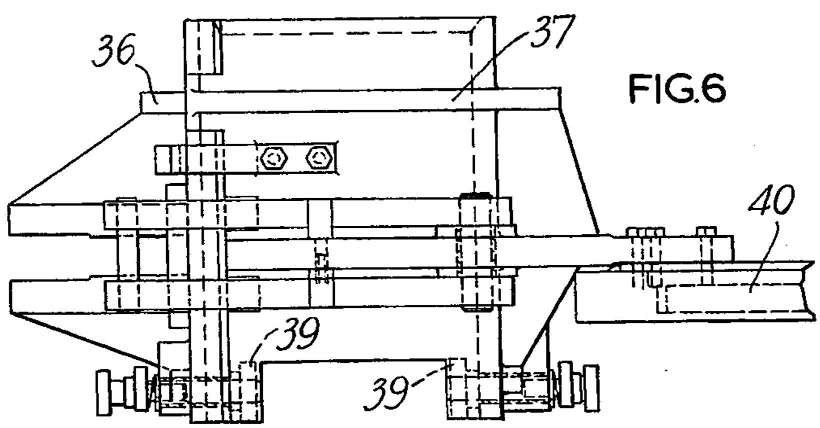


FIG.6

1258051 COMPLETE SPECIFICATION

8 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 4

FIG.7

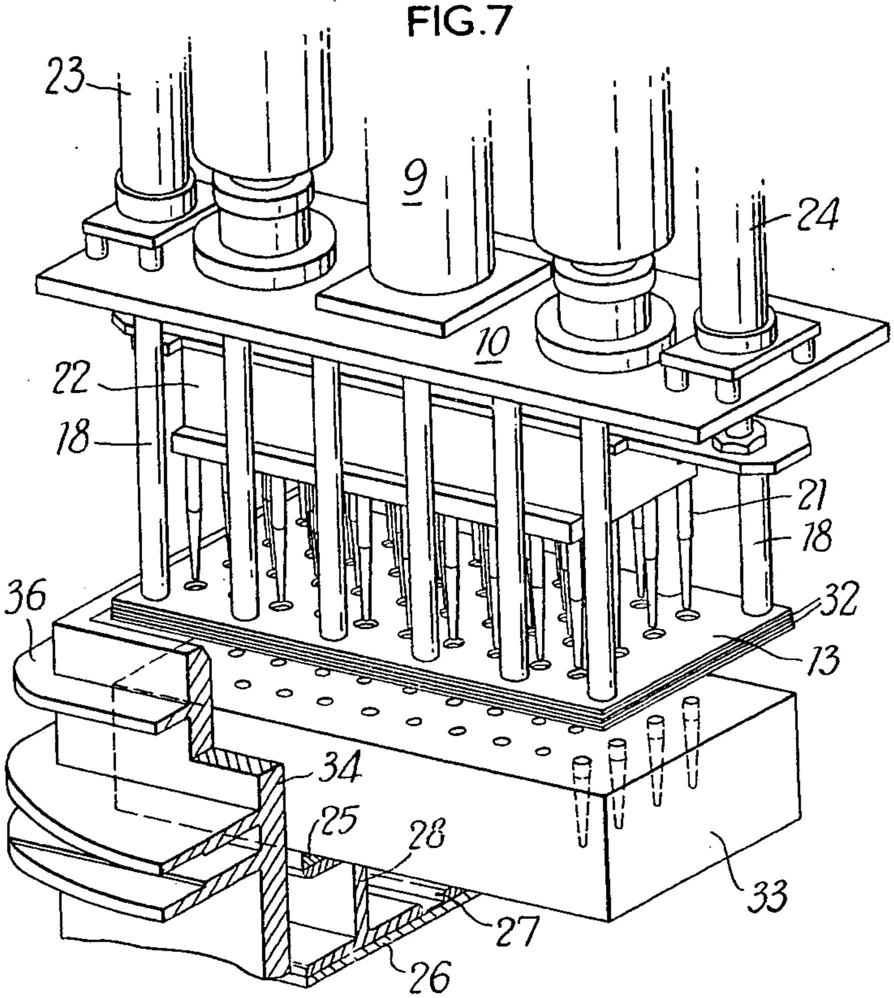
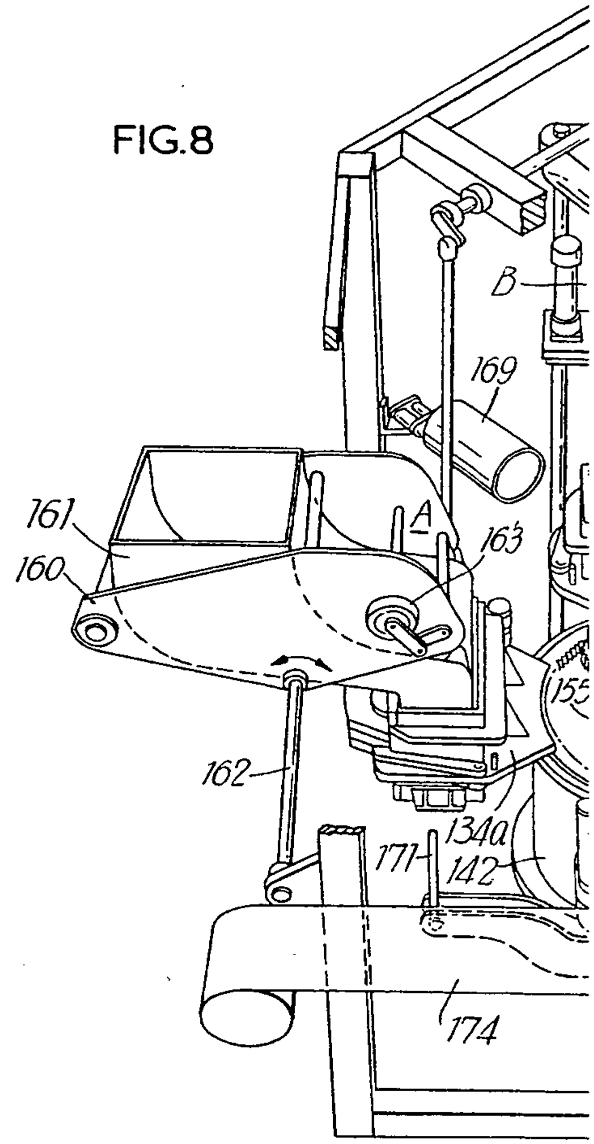
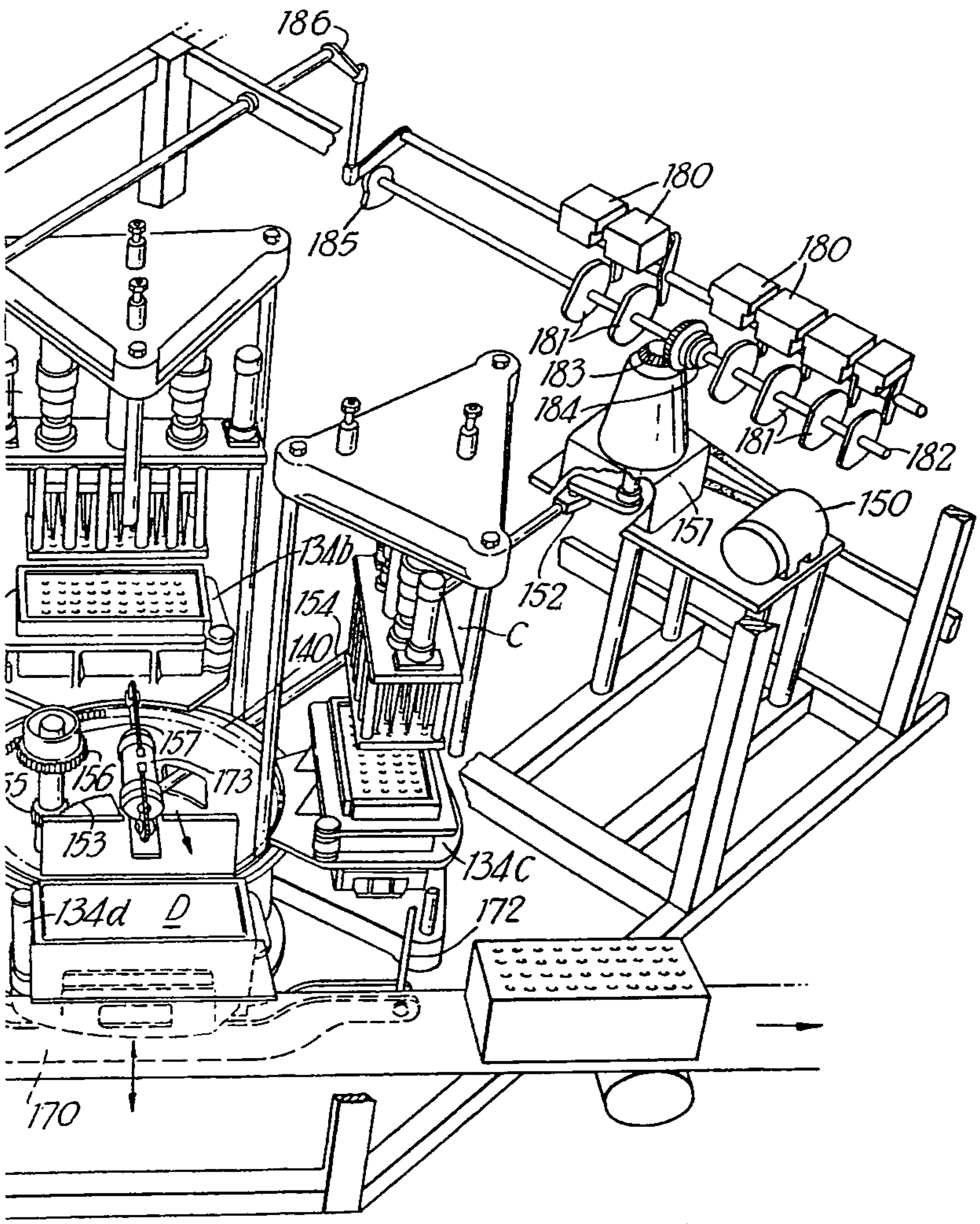


FIG.8

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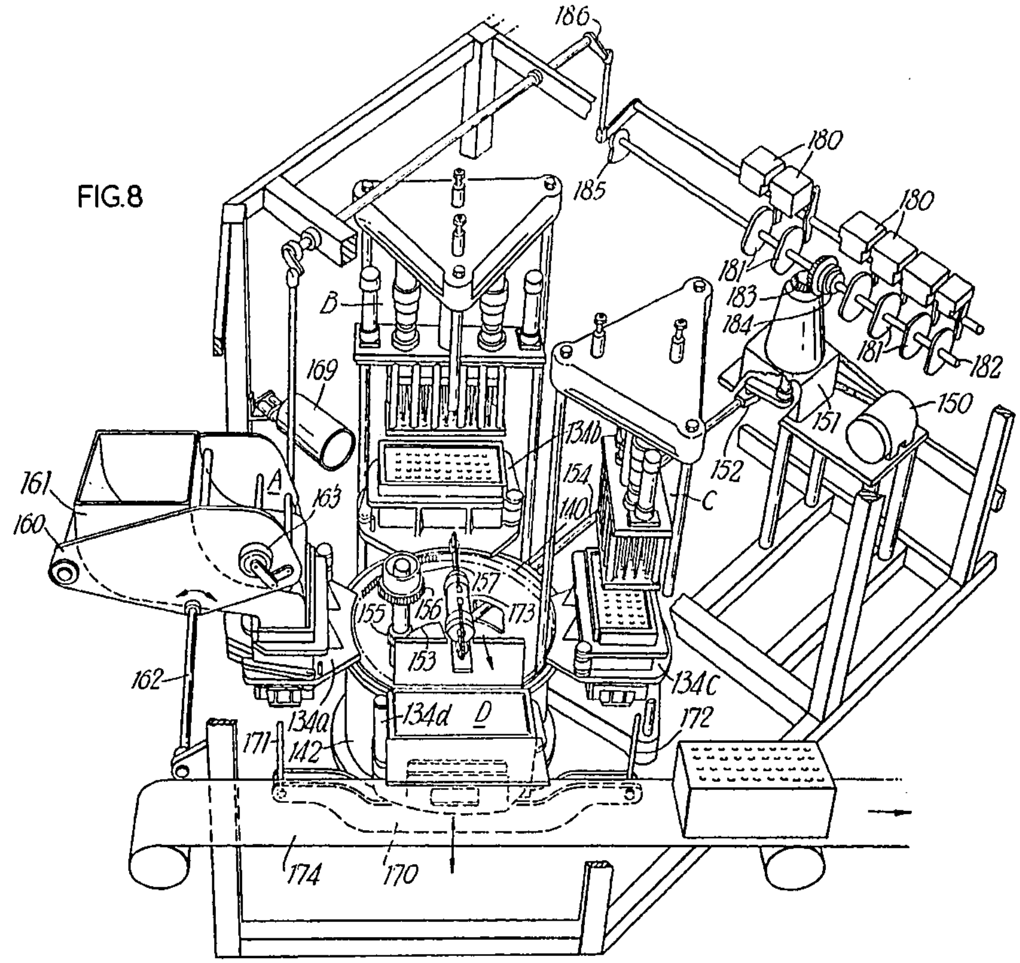
134C
134d
D
172
170

FIG.8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134a
134d
D
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171
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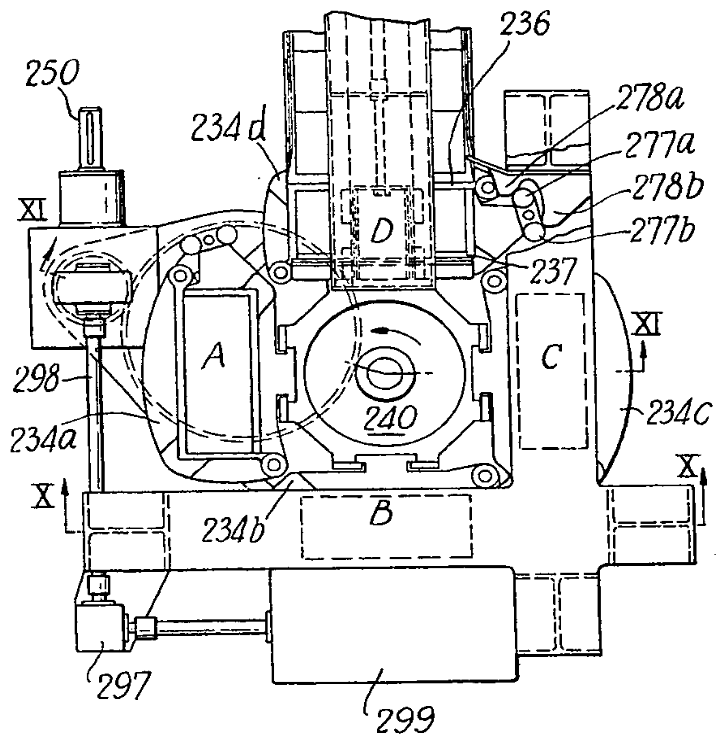
174
170

FIG.9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C
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234C
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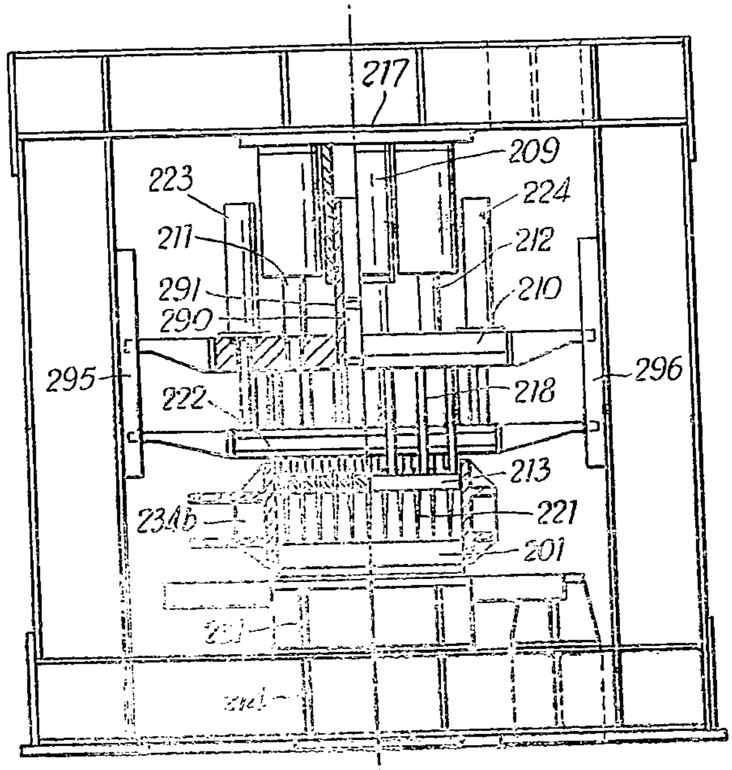
X
X
234b
B
297
299

FIG.10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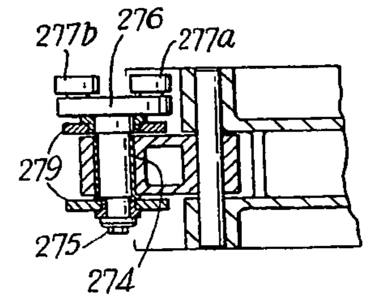

FIG.12

FIG.13

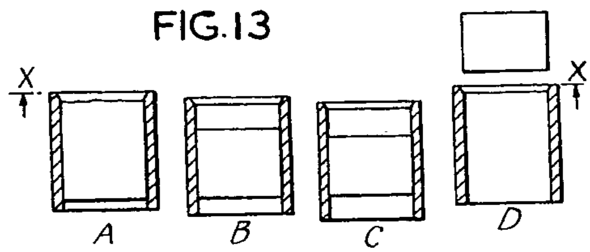

FIG.11